

# Arctic Sea Ice Decreasing Rapidly

by Bill Rizer

The International Council of Science and the World Meteorological Organization are co-sponsoring a large research program designated as the International Polar Year (IPY) focused on the Arctic and Antarctic for the period from March 2007 through March 2009 (see <http://www.ipy.org>). The timing of this effort could not be better, because something is happening in the Arctic that will most likely have effects on climate worldwide. The Arctic is experiencing a rapid and significant decrease in sea ice, at a rate much higher than predicted by any of the models described in the Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report (Solomon et al., 2007).

By now most of us have heard that our climate is changing; it is getting warmer. However, global warming is far from uniform, with temperature increasing at a much faster rate in the north polar regions (Hansen et al., 2006). The warming of the Arctic, its effects on the extent of sea ice and the positive feedback between the two processes may have profound effects on the climate for the rest of the globe.

Terminology used in this article is from the National Snow and Ice Data Center (NSIDC).

*Sea ice* is a relatively thin (nominally 1–5 m) layer of frozen seawater floating on the surface of the ocean. It differs from sheet ice, the thick layer of ice and snow over Greenland and the

Antarctic, or shelf ice, which is the extension of sheet ice over the ocean.

*Ice concentration* is the percentage of the area covered by sea ice.

*Ice extent* is the total area covered by at least some minimum concentration of sea ice (usually 15%). Ice extent includes areas of open water between the sea ice.

*Sea-ice draft* is the thickness of that part of the ice that is submerged under the sea.

*Sea ice maximum extent* is the day of the year when the sea ice covers the largest area of the Arctic. This is usually in March, at the end of the winter season.

*Sea ice minimum extent* is the day of the year when the sea ice covers the smallest area of the Arctic. This usually occurs in September, at the end of the summer melting season.

*Perennial sea ice* is ice that does not melt annually but remains from year to year.

Perennial sea ice is usually thicker (> 1 m) than the ice that melts in the summer and refreezes in the winter (1 m). That observation suggests that once a portion of the ice extent melts, it becomes weaker in the sense that it can melt again more easily.

Sea ice extent varies through the year, reaching a maximum at the end of the winter in March and a minimum at the end of summer in September each year (Figure 1). Since the 1970s, however, there has been a significant decrease in both the extent and thickness of Arctic sea ice (Stroeve et al., 2005) as indicated in

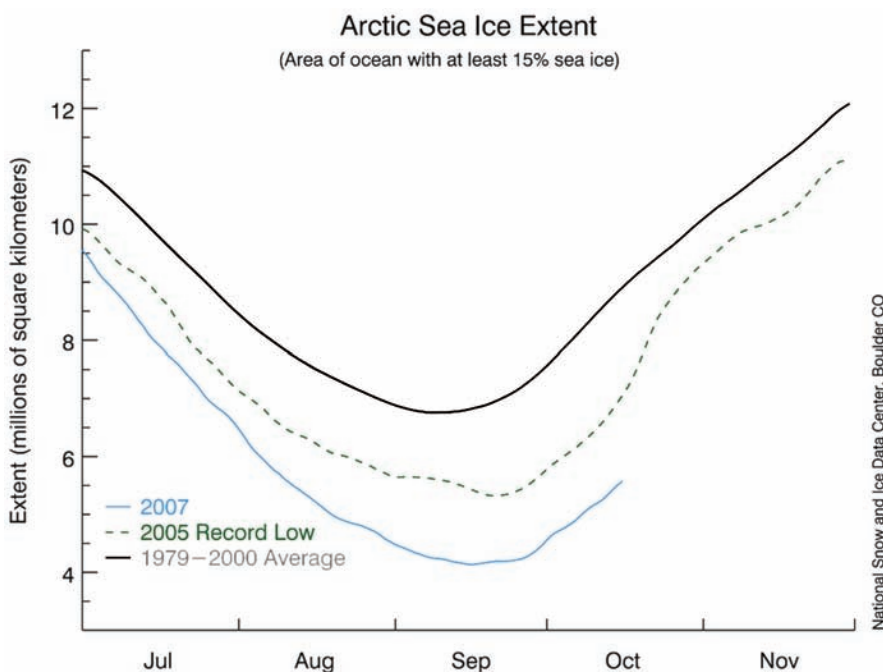


Figure 1. Yearly variation of Arctic sea ice extent with season for 2007, 2005 and 1979–2000. Credit: NSIDC.

National Snow and Ice Data Center, Boulder CO

Figures 2 and 3. In fact, the sea ice extent has been decreasing by about 8% per decade. Of particular concern, however, is the observation that the decrease in ice area has been accelerating since 2002. Between March 2005 and March 2007, the sea ice (maximum) extent decreased from  $4.69 \times 10^6 \text{ km}^2$  to  $3.61 \times 10^6 \text{ km}^2$ , based on satellite data (Nghiem et al., 2007). This loss, about a million square kilometers or 23% of the total extent, occurred in only two years. The sea ice minimum extent for 2007 shattered the previous record set in 2005 and represents a loss of about  $2.6 \times 10^6 \text{ km}^2$  from the average extent over the years 1979–2000, an area the size of Alaska and Texas combined (Figure 3). The thickness of the sea ice decreased as well, so that much of the Arctic ice is only about 1 m thick. In the summer of 2007 the Northwest Passage became ice free for the first time since regular monitoring began in

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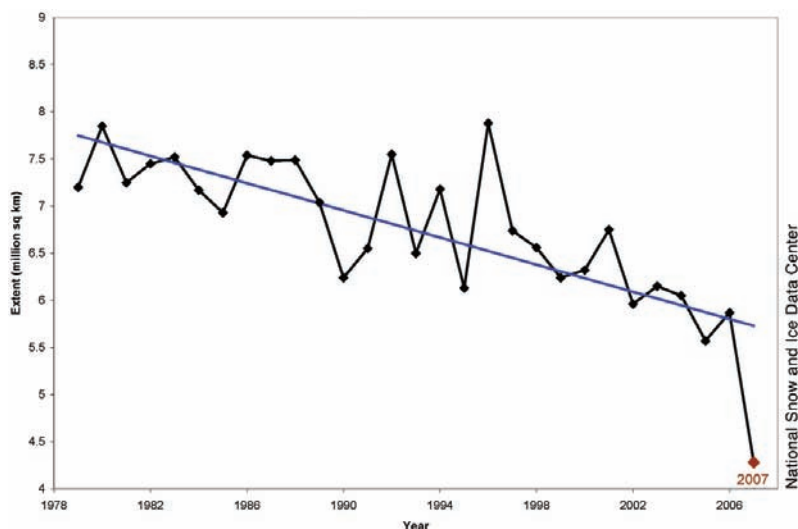


Figure 2. Arctic perennial sea ice extent since 1978. Credit: NSIDC.

1972. Sea-surface temperatures in one location north of the Chukchi Sea were 5°C above normal (Kalaugher, 2007).

The accelerating rate of ice loss noted over the past few years (Comiso et al., 2008) is indicative of a positive feedback mechanism—warming temperatures melt the ice, decreasing the albedo (surface reflectance) and allowing more solar radiation to be absorbed by the ocean, which increases temperature and causes more melting. In fact, the system is more complex and most likely involves a combination of increased temperature, lack of cloud cover, warm influx of water from the south and strong

winds favorable for moving the ice out of the Arctic (Kalaugher, 2007).

The loss in ice extent is observed in all regions of the Arctic Ocean on both the Atlantic and Pacific sides. In the past when one region experienced a decrease, another region often saw an increase in ice extent. The summer thawing season has been getting longer and starting earlier at the expense of the freezing season. The ice is not fully recovering in the winter from the losses in the summer; the maximum ice extent in the wintertime trend alone is now approaching –3% per decade (NSIDC). This has led some climatologists to suspect a tipping point has been passed and that in the near future (within 50–70 years) the Arctic Ocean will be ice free during at least part of the summer (Lindsay and Zhang, 2005).

An ice-free Arctic has significant implications for a number of industries, including oil and gas. As the ice extent decreases there will be growing opportunity for exploration and production. At some point in the near future there will be a northwest passage through the Arctic and a northern passage that will be open much longer than at present (Figure 4). This will have a significant positive impact on shipping and trade.

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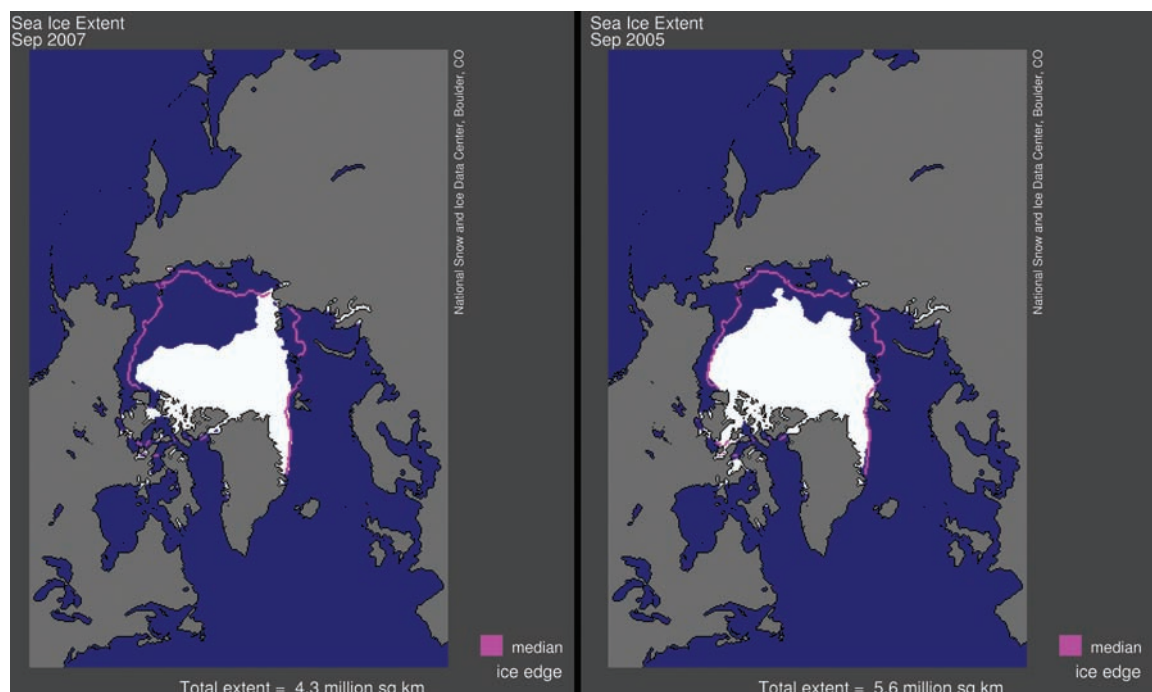


Figure 3. Five-day mean sea ice extent minimum for September 2007 and 2005. The magenta line indicates the mean September extent based on data from 1979 to 2000. Credit: NSIDC.

The downside of the decrease of ice in the Arctic is sobering. The Arctic sea ice cover plays a major role in governing the exchange of energy between the ocean and atmosphere in the polar regions (Dethloff, et al., 2005). Changes in the thickness and extent of the Arctic sea ice cover may lead to more drastic climate change. Certainly there is the potential for changes in ocean circulation and changes in precipitation patterns that could drastically impact agriculture. Although the volume of Arctic ice is not sufficient to significantly affect sea level directly, continued warming of the Arctic may lead to warming of the Greenland Ice

Sheet. Were that to melt, sea level would rise about 6 m.

Modeling of these complex coupled systems is still coming to grips with the various positive and negative feedback mechanisms. What is happening in the Arctic may simply be a warning that we have to pay close attention to with regard to its affect on how we interact with our environment. In a worst-case scenario, the sea ice decreases in the Arctic may reveal new feedback mechanisms that could lead to a rapidly changing climate not altogether to our liking. ■

## References

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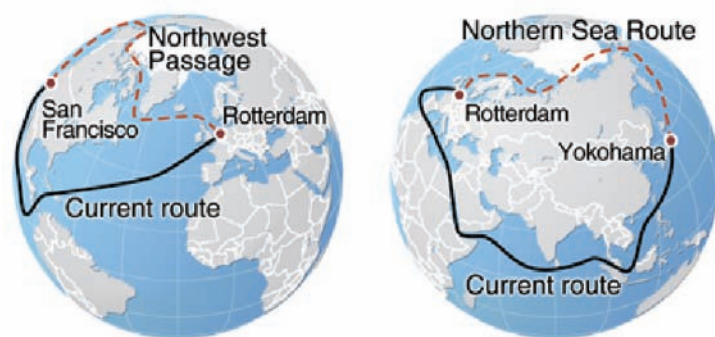


Figure 4. Northern and northwestern passages that will be open when sufficient sea ice melts. Credit: UNEP/GRID-Arendal, 2007.

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